

Progress Toward a Magnet-Hall Effect Random Access Memory (MHRAM)

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Efforts are being made to build a random access memory using a deposited magnet and a Hall Effect sensor for each bit. This concept is at least 35 or 40 years old, Until recently, there has been considerable doubt that sufficiently high readout signals could be generated, Recent advances in magnetic materials and silicon on sapphire (SOS) processing have led us to reinvestigate this concept as applied to a radiation hard, nonvolatile, nondestructive read-out memory, for hostile environments. The present experiments are directed at this issue,

The MHRAM is built on a substrate of SOS with a deposited magnet in each cell. The memory information is stored in the polarity of the magnet which has in-plane uniaxial anisotropy. The direction of magnetization is read by a I-tall sensor directly under the end of the magnet, Current through an aluminum write line provides a field to change the polarity of the magnet and therefore the stored memory,

In one configuration, the Hall sensor is silicon. Silicon Hall bar and Hall MOSFET sensors have been built in various orientations to the crystal axes and measured for both Hall voltage and offset voltage (the voltage across the Hall leads at zero magnetic field). The offset is found to be very dependent upon the orientation of the Hall sensor relative to the crystal axis. By combining two Hall structures appropriately, it is possible to reduce the offset voltage to less than one millivolt as compared to a desired five millivolt output signal.

In the alternate configuration, iridium antimonide (InSb) is used as the Hall sensor. Deposited and annealed InSb has demonstrated high electron mobilities¹. We have found the highest Hall nobilities of $1.1 \text{ m}^2/(\text{V}\cdot\text{sec})$ in films evaporated from a single crystal of InSb onto a sapphire substrate. The carrier concentration for these films are four orders of magnitude greater than intrinsic, resulting in high sensor read currents,

Depending on the sensitivity of the Hall sensor, the magnet desired could have a coercivity of a few tens of Oersteds or as much several hundred. Permalloy has been e-beam evaporated and measured with an Magnetic Force Microscope. The magnets were found to be single domain for films of 40-60 nm in the shape of a $1 \times 5 \text{ }\mu\text{m}$ rectangle. Films of cobalt platinum (CoPt), a higher coercivity material, have also been investigated.

The present conclusion from the experiments is that a practical silicon-based MHRAM is feasible. A silicon Hall MOSFET sensor with a magnet which could be single-domain permalloy or a harder magnetic material such as CoPt appears to offer the greatest promise for success,

1. S. Yeh, D.J. Cheng, G.F. Chi, and M. Chu, Mat. Res. Sot. Symp. Proc., **135**, 483, (1989).